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ABSTRACT

The advantages of teaching computer literacy to learning disabled adolescents are discussed in the context of a private school program. It is emphasized that the use of computers is helpful in teaching metacognitive skills, requiring learning disabled students to be logical and sequential, analyze, self-question, and monitor their own learning. Cited among the advantages of computer use are the characteristics of objectivity, predictability, individualization of instruction, and specificity. The general academic program at Hill Top Preparatory School in Pennsylvania (grades 7 and up) is described, including the content of basic computer math and science courses. (CL)

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METACOGNITION AND COMPUTERS WITH LEARNING DISABLED ADOLESCENTS

Metacognition

In the June, 1979, issue of Plain Talk About Children with Learning Disabilities, the National Institute of Mental Health pointed out that learning disabled children need to be taught how to learn. Learning how to learn is metacognition. It involves enabling the mind to search out patterns, to analyze and solve problems, to summarize results, to check conclusions and to establish associations. It involves learning strategies for receiving, processing, storing, and recalling information. It requires skills in selfquestioning as well as awareness of failure. It is not just study skills. In an article appropriately titled "Metacognition or Taking Study Skills Out of the Closet" in the December, 1982, issue of Basic Education, Harriet Bernstein wrote:

Study skills are blind training whereas metacognitive instruction teaches students to monitor their own comprehension, to understand the underlying purposes of various study methods, and to select an appropriate method independently.

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Hill Top Preparatory School

Metacognitive instruction is at the core of the academic program at Hill Top Preparatory School. Hill Top was founded in 1971 by Elissa Fisher after years of work with youngsters who needed a program that was like an academic preparatory school in some respects, but unlike it in others. Hill Top is a traditional academic school in many ways. Teachers are certified in an academic subject (and many are also certified in special education). Grades are given and are reported. Students have a schedule with rotation of classes. Laboratory sciences, physical education, and foreign languages are offered. Students are expected to take the Preliminary Scholastic Aptitude Test (PSAT) and the Scholastic Aptitude

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Test (SAT) in their junior and senior years and most continue their formal education after graduation.

In other ways Hill Top is unique. Classes are small with a maximum of eight. Group therapy is required of every student two times weekly and is built into the schedule just as physical education is. Every student takes math, science, social studies, and two English courses each year. There are no study halls, although everyone has a ten minute break both in the morning and in the afternoon.

Because Hill Top is reality oriented, there is a careful evaluation of each student before entering the program and throughout the program. Instruction begins at the student's functioning level, regardless of chronological age, and focuses on strengths. Hill Top is an academic school in a clinical and therapeutic environment. Intervention and confrontation are normal as the student learns to be responsible for him/her self. Diagnostic work comes first and then is used to instruct in both skills and content. From the first days the Hill Top staff has used a metacognitive style in enabling the students to learn how to learn, to be responsible for their own learning.

Mathematics

In learning how to learn math, the Hill Top model is especially appropriate. Upon admission, Hill Top students almost always list math as the subject least liked. They have not learned how to learn math. They often do not know the basics of computation and, therefore, are "set up" for failure in this sequential subject if they are programmed by age and not functioning level. Mathematics makes extraordinary use of abstractions. It is the study of what is true of hypothetical states of things. This is a disadvantage for adolescents who have not learned to be analytical.

Yet math is also a subject whose topics do not have emotional overlays which have interfered in the instruction in other subjects such as literature. This lack of emotionality is an advantage in teaching math to learning disabled.

Success in math requires that students learn how to learn. They must learn to be methodical, logical, meticulous, and patient. They must learn to organize information readily and pay close attention to detail. They must learn to develop understanding of the processes as the "New Math" of twenty years ago emphasized. They must also learn to add, subtract, multiply, divide as the "back to basics" movement of ten years ago emphasized.

Computers

An effective way to achieve these goals and strategies is computer literacy, considered the fourth "R" in today's education. Use of technology with logical processes and mathematics is not new. The abacus was developed before 600 B.C. Logarithms were first used in Scotland by John Napier around 1600. Blaise Pascal developed the first adding machine in France in 1642, and Gottfried Wilhelm Leibnitz, in 1694, manipulated symbols on a calculating machine. In 1781, only technical difficulties prevented J.H. Muller from building an automatic computer. That was left to Charles Babbage of England who spent much money in the 1800's, but never completed his analytical engine. Herman Hollerith and the U.S. Bureau of Census developed punched cards in 1890, and finally in 1940, George Stibnitz built a partially automatic computer at the Bell Laboratories. Digital, analog, function, and integrating computers followed and in 1946, ENIAC, the Electronic Numerical Integrator and Computer was developed.

Computers are not new then to this generation, but the access to them in our everyday lives is. The 1946 ENIAC weighs thirty tons, occupies

15,000 square feet, and contains 40,000 vacuum tubes. A modern computer can weigh less than twenty pounds, cost less than a few hundred dollars and take up inches on a desk. Even more significant, it can solve ordinary math problems eighteen times faster than the 1946 ENIAC. Time Magazine's 1982 "Man of the Year" is now a tool for all of us.

Advantages of Computers with Learning Disabled

There is no question, then, that education must include work with computers. Many advantages of using computers with learning disabled adolescents are obvious.

1. Computers are safe. Mistakes are expected and are okay. The learning disabled student can be in "error" and not feel stupid since everyone gets "error" messages from the computer, including the instructor.
2. Computers lack emotionality. The words used to interact with a computer are uncontaminated. They carry no associative emotional content that can derail the brightest learning disabled person in other settings.
3. Computers are predictable. The sequence is defined. Computers require one step at a time.
4. Computers can individualize. Computers are infinitely patient and will wait for a response without glaring, without calling on another person, and without disapproval.
5. Computers require specificity. This specific language usage is especially helpful for language impaired students and there are studies which suggest many learning disabled students have language deficits.

There is another important advantage with computers which is sometimes overlooked. Computers encourage a metacognitive style of instruction. Computers help students to think and to be analytical. Writing a program for a computer requires students to "teach" it as they would a peer who has no knowledge until given each piece in the proper sequence. Metacognition,

learning how to learn, is greatly assisted by learning to write simple programs for the computer. The student is forced to be logical. Each step in the process must be identified and isolated. The language must be specific and the sequence must be carefully developed. A student cannot "con" or "charm" or "intimidate" a computer. When errors are made students are forced to correct their own work. They learn to monitor and evaluate their own learning. If something goes wrong every single piece of data may have to be rechecked.

As students develop their own programs for a computer they learn how to learn. They learn to follow instructions and to sustain their focus. They learn to pay close attention to detail, to organize information, and to be careful in sequencing. They learn to correct their own work, and to interact with and attend to responses from something else.

Students also learn if the program does not work, they must try another way, something many learning disabled students have not done before. Usually learning disabled students quit without trying alternatives when their first method does not work. With computers the first run is expected to have an error. Students learn to go beyond failures to successes which permit more failures. They write a program and run it. If it does not work, they try another way to achieve their goal. Each time they run the program, they get fewer errors until the program is successful. This allows them to write more programs and make many more failures. It is this risk of failure which encourages them to be more aggressive about their learning.

Many learning disabled adolescents demonstrate average or above cognitive skills. They want to learn and they have high motivation if they perceive success as possible. Computers can provide the bridge for learning disabled to move from poor academic performers to masters of their

own learning. Writing programs for a computer can do the following:

- Help a student who has failed actually to achieve.
- Help a student who would rather be "bad" than "dumb" be appropriate.
- Help an awkward and clumsy child to practice coordination skills.
- Help a student who focuses attention on too many things to sustain focus on one thing.
- Help a student who cannot picture things in his/her mind to develop a visual image.
- Require a student who skips words to use specific language.
- Require a disordered, disorganized student to organize.
- Require a student who has difficulty dealing with alternatives to permit failures and to try another approach.

But, most of all, writing programs for a computer provides a way for learning disabled adolescents to learn how to learn by requiring them to be logical and sequential, to analyze, to self-question, and to monitor their own learning. Through successful computer work learning disabled adolescents develop career options and self esteem. Through writing programs for the computer they learn strategies for becoming responsible for their own learning.

The Hill Top Program

The goals of the Hill Top program center on recognition and understanding and not merely on the reproduction of a program or drill. Through the programs of computer math and science courses, students take that long, detailed look at how learning takes place and come to pinpoint "This is how I learn."

For many students math has become a serious series of failures. Math is a cumulative assemblage of concepts. Therefore students come to Hill Top in the 7th, 8th, or 9th grade (some as late as the post-high school transitional college years) with a solid history of failure in and dislike for math. These students are not only verbally, perceptually, or visually

learning disabled, but mathematically learning disabled. A student's skills socially, as well as spacially, are dependent on the growth of the student's powers of representation. These students do not have these powers of representation.

Mathematics offers a multitude of variables from which a student can draw in order to label and represent unknowns and changes in his/her life. Many students lack this open "grab bag" of X's and Y's and so the WHY's are left unanswered or unasked. Mathematically or logically assigning constraints to a problem situation is not and can not be done. The student has not learned how to learn. The student cannot label the region that requires the constraints.

At Hill Top the goal is to have students be the teachers as well as the learners -- understanding, recognizing and teaching each other the how's, the X's and the WHY's. Aiming toward this goal of metacognition, it is necessary for the student to deal NOT just with one image or variable in a situation but with the properties and features of several complicating factors simultaneously. This manipulation, this non-learning disabled ability, bridges the very large gap between what students conventionally do and what they are capable of doing. To continue Harriet Bernstein's thoughts from the December, 1982, issue of Basic Education :

Much of present-day teaching goes in one ear and out the other because children lack the key to managing their own amazing mental processes. The stuff of metacognitive instruction -- awareness of failure, searching for main ideas, self-questioning, predicting, summarizing, checking, and problem-solving -- is an attempt to teach explicitly concepts that traditionally have not been taught.

Managing and organizing then are the keys. Teaching a computer to carry out instruction then touches the base of a metacognitive pyramid since the computer is "dumb".

Who and When

Hill Top students at the 8th and 9th grade pre-algebra level are introduced to computer components and the simple reproduction of BASIC programs early in the fall semester. This one-day-a-week math experience offers these students the opportunity to:

- Work with an electronic tool.
- Practice pre-algebra concepts by constructing and solving problems.
- Manipulate variables.
- Identify and use algebraic symbols.
- Develop an enthusiasm about their own successes with a computer.
- Build up a series of successes through correcting errors.

At this 8-9th grade math level (chronological age 14-15 years), the learning disabled student is sufficiently able to perform computational skills with basic math processes. This capability then releases the student's math energies from focusing strictly on skills to considering the abstract concepts of pre-algebra. At this level, where the use of signs and symbols tends to proliferate, cognitive organizational strategies are being learned. Mnemonic strategies or metamemory aids are introduced and exercised:

< , less than looks like an "L" or the open side
is always toward the larger value.

As the symbol-memory is exercised so constantly at this level, the introduction of computer terminology and symbols with each specific definition, tends to meld with the pre-algebra concepts, symbols and terms:

"Parentheses mean this ..."
"Quotes mean this ..."

The order of operations and comparisons of quantities introduced in the

pre-algebra class are strictly followed by this computer which never "took" in pre-algebra.

Since 1974, when computers were first introduced on campus to the Hill Top community, the computer as an effective model for learning how to learn has captivated the interest of even the most anti-math student. The development of awareness of action, sequence, content and language of the computer is not "magical" at this level. It is something the student can learn to understand. It demands analytical, sequential thinking processes and offers an intangible reward to the student, an ego boost that few have ever experienced. This ego boost then acts as the springboard to more in-depth work and future classes in the computer maths and sciences.

To date, 39 pre-algebra students over two years have taken this step toward metacognition through their work with three TRS80 16K color computers and two Apple IIe's. 43 other students in the eight year period since 1975, have been educationally aggressive members of computer math level I and II classes.

With two students per computer station, the exchange of ideas, the reinforcement of procedures, the review of steps to take and the shared excitement and the intrigue with "debugging" have provided a highly motivating classroom environment.

What and Why

At this time in the development of the computer math and science program, many students are interacting daily with the computers on campus through the following classes:

- Three pre-algebra classes
- Two computer science classes: intro courses
- One computer science class: advanced course
- One astro-physics class.

The overall goals for each of these students are:

1. An understanding of the programming language.
2. An efficient use of computer time.
3. An appreciation of the interrelationships of math terms, symbols and concepts of programming.
4. A development of logical, sequential thinking processes.

The introductory computer science course covers input/output operations, basic arithmetic operations, comparing, sounds, graphics, color, string processing, file processing, and many other well-defined concepts. The student is shown the proper way to operate a computer, design code, and debug programs and games. Through the use of the computer, hand-eye coordination, sequencing, integration skills, inductive and deductive reasoning are strengthened.

The advanced computer course begins with a review of the functions of a computer system. Subsequent activities focus on "sort" application, multiple record processing, word processing, and data base management. The student is involved in the writing of user friendly programs for the subject area of his/her choice. The skills of hand-eye coordination, sequencing, integration and inductive-deductive reasoning skills developed in the introductory course continue to be strengthened throughout the course.

The COBOL/PASCAL computer course also begins with a review of the functions of a computer system. Subsequent activities focus on input/output operations (addition, subtraction, multiplication, division) computer statements, taking a final total, comparing, heading and print control, major, intermediate, and minor total logic, the sort verb and table lookup using set and search verbs, and reading and writing on

sequential disk files. This course was designed for those students having an interest in post-high school business courses.

Through the process and skills of flow charting used in each course, the student is faced with breaking down and itemizing each data component the computer needs to satisfy the outcome expected or anticipated. Learning to trace programs and nest procedures within loops, the student may learn to handle the panic of social situations requiring analytical skills. The patient and painstaking labeling and manipulation of variables used as counters, testers and data force the student to deal with the concept of the program (THE BIG PICTURE) and categorization of components for a logical description of a process. The student's programming figure-ground problems can be dealt with on a non-personal level, the variables are misplaced, misnamed, missing, not the student's integrity.

Through the use of SOUND-tones and joysticks, other non-mathematical applications can be introduced with the student using the mathematical procedures needed for the completion of the application. Sorting and storing data as well as whole programs is a sequentially-tied process. With the abstractions of storage and retrieval from storage, the student begins to build in the standardized steps that work, not only at an electronic level, but even more at a personal level. Organization and documentation is essential. "Shorthand" is necessary. Proper selection of language terms are proscribed. This framework building of life skills demanded by a non-living entity, in turn, spills over into the student's non-computer experiences.

Managing and organizing free time is aided by computer literacy. For many learning disabled students, free time is empty time. Many of these students have never developed free time activities. The construction of computer programs not only serves as a learning experience but, in turn,

offers that ego boost and free time activity, even if it is constructing modifications of a game program. The enthusiasm is addictive. The student exhibiting little enthusiasm at the onset of his computer course will most likely be the student who must be escorted from the computer room to his/her next class.

At this point in the Hill Top computer program, we are a software generator, each student devising programs to help him/her self review vocabulary lists, sort alphabetical lists, practice math skills. Where we are going as testers of marketed software with learning disabled students is still being discussed. Our graduated students are out in the field now. Some are concentrating on computer-based courses of study, some are in science-math higher education, and some are in business and job situations demanding this literacy. Our students are teaching, learning and learning how to learn. Learning disabled students need metacognitive strategies.

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